



## Environmental Energy Technologies Division

## NEWS

WINTER NEWSLETTER:  
VOL. 8, NO. 3

Hidden Costs of Energy  
Production NRC Report

*The Rosenfeld* Named After  
California's Godfather of  
Energy

Solar Photovoltaic Report II  
Release

Methane in Central California

Wind Power Property Values

Community Wind

FABS21 Release

Franchise Tax Board Data  
Center Project

Sources and Credits

This issue addresses everything from a National Academy of Sciences report on the hidden costs of energy production to tools for making semiconductor fabrication facilities and data centers more energy-efficient. Art Rosenfeld, the former Director of the Center for Building Science at Berkeley Lab's Environmental Energy Technologies Division is honored with a new scientific unit, the Rosenfeld, representing the amount of energy saved by displacing the electricity production of a 500-MW coal-fired power plant per year through energy measures.

— Allan Chen



*EETD News* reports on research conducted at Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division, whose mission is to perform research and development leading to better energy technologies that reduce adverse energy-related environmental impacts. The Division's staff of nearly 400 conducts research on energy efficiency in buildings, indoor environmental quality, U.S. and international energy issues, and advanced energy technologies. The newsletter is published online once a quarter. For more information, contact

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The *Center for Building Science News* was published between 1993 and 1998. It covered news of the Division's research in energy efficiency and buildings, the indoor environment, and energy analysis. You'll find all back issues, from Winter 1993 through Summer 1998, available here [\[http://eetd.lbl.gov/newsletter/cbs\\_nl/cbsnews.html\]](http://eetd.lbl.gov/newsletter/cbs_nl/cbsnews.html).

Winter Newsletter: Vol. 8, No. 3 [\[http://eetd.lbl.gov/newsletter/nl30/\]](http://eetd.lbl.gov/newsletter/nl30/)

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## Environmental Energy Technologies Division

## NEWS

**The Hidden Costs of Energy Production—\$120 Billion in 2005**

A report recently released by the National Research Council (NRC) estimates that the hidden costs of energy production and use in 2005 were \$120 billion. Known to economists as *external costs*, they include the economic impacts from human health effects, physical damages to structures, and reduction in grain crop harvests caused by air pollution. They are "hidden" because they are not reflected in the market prices of coal, oil, other energy sources, or the electricity and gasoline produced from them. Health damage from air pollution associated with electricity generation and motor vehicle transportation was found to be the largest single impact.



Thomas McKone, a senior scientist in Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division (EETD), and Adjunct Professor in the UC Berkeley School of Public Health, was one of 18 distinguished experts in public health, economics, and energy science who wrote the report. It was released by the NRC at the request of Congress. As a branch of the National Academies of Science, NRC organizes studies using the best available science by drawing on NAS membership and carefully selected experts.

Although these hidden costs are not reflected in the market cost of generating energy, they have an impact elsewhere, for example, as costs to treat diseases caused by criteria air pollutants (mainly sulfur oxides, nitrogen oxides, and particulate matter) and other products of fossil fuel combustion, costs of reduced grain harvests and timber yield, and costs of damage to buildings.

The report analyzed full life-cycle costs for energy production and use. This includes costs for producing fuel feedstocks (such as coal, natural gas, petroleum, and biomass), processing them into gasoline and other fuels, and transporting them. It also includes the health costs of generating electricity from these fuels and using them in transportation. The study even included impacts from manufacturing vehicles.

"The results described in this report are backed by strong technical analysis and a high degree of confidence by the committee," says McKone. "The committee's deliberations were marked by a desire to ensure that the report's results could be defended according to the best current science."

**Health-Related Impacts Top the List**

The majority of the effects are the result of human health impacts (including premature death) from air pollution and increased risks of diseases ranging from cancer to respiratory symptoms and other ailments such as asthma attacks.



Berkeley Lab scientist Thomas McKone was one of 18 distinguished experts in public health, economics, and energy science co-authoring an NAS report on the hidden costs of energy production. (Photo by Roy Kaltschmidt, Berkeley Lab Public Affairs)

The committee provided an estimate of the external costs of fossil fuel use in 2005, as well as, where possible, an estimate of these costs in 2030. To analyze the externality costs of fossil power plants, the committee evaluated impacts from 406 coal-burning plants in the United States, which account for 95 percent of U.S. emissions. It analyzed the effects and estimated the emissions, the exposures resulting from these emissions, and the resulting mortality and morbidity (that is, the number of people with reduced life spans and symptoms that could be expected from these emissions). They did the same for natural gas-burning plants, nuclear plants, and renewable generating facilities. They also analyzed the same parameters resulting from the extraction of petroleum, refinement into gasoline, and combustion of gasoline in vehicular transport. They expressed their results as external damages in dollars per vehicle mile traveled.

The report estimated cost ranges for greenhouse gas (GHG) emissions and addressed those separately, because of uncertainties in the kinds and magnitudes of impacts from climate change.

Coal accounts for about half the electricity produced in the United States. According to the report, in 2005 the total annual external damages from sulfur dioxide, nitrogen oxides, and particulate matter created by burning coal at the 406 coal-fired power plants that produce 95 percent of the nation's coal-generated electricity, were about \$62 billion; these nonclimate damages average about 3.2 cents for every kilowatt-hour (kWh) of energy produced.

Damages attributable to natural gas were smaller. The report stated that the burning of natural gas generated far less damage than coal. A sample of 498 natural gas-fueled plants, which accounted for 71 percent of gas-generated electricity, produced \$740 million in total nonclimate damages in 2005, an average of 0.16 cents per kWh. There was again a vast difference among power plants. Half of them account for only 4 percent of the total nonclimate damages from air pollution, while 10 percent produce 65 percent of the damages.

### **Greenhouse Gases**

The committee estimated the external costs from the emissions of GHGs, but instead of providing a single target figure for these emissions, it provided a range of possible costs. The reason, according to McKone, was that because knowledge about climate change is evolving rapidly, the estimates of the effects of GHGs on climate change were more uncertain, and depended on which assumptions were made. The committee found that marginal damage estimates for emissions in 2030 could be as much as 50% to 80% larger than present-day estimate ranges.

"Although it was not possible to accrue greenhouse gas damages to a particular year they way it was done for damages from other air pollutants, the damages from GHGs appear to be on the same order of magnitude as those for human health," says McKone.

### **Transportation Impacts Similar Across Fuels and Technologies**

"In 2005 motor vehicles produced \$56 billion in health and other nonclimate-related damages. Damages per vehicle mile traveled were remarkably similar among various combinations of fuels and technologies—the range was 1.2 cents to about 1.7 cents per mile traveled—and it is important to be cautious in interpreting small differences," the report says.

An interesting result of the transportation analysis is that the damages from all types of fuel were similar, whether for gasoline-powered cars, or plug-in hybrid electric vehicles (PHEVs), which will use a combination of gasoline and electricity stored in batteries. About 50 percent of the electrical power that would recharge PHEVs on the U.S. electricity grid would be from coal-powered generation. Without changing the power mix that supplies electricity to the grid, the external costs would be roughly the same, whether the energy source were just gasoline or gasoline plus the current U.S. grid's fuel mix.

Biofuels from corn-based ethanol were no better than gasoline because of the large power input required to produce it, but biofuels derived from grass or wood feedstocks show the promise of reduced health costs and significantly lower carbon emissions per vehicle mile. Although the committee was able to provide impacts on a per-vehicle mile traveled for the year 2005, it concluded that it could not provide a credible prediction for what the transportation vehicle mix would look like in 2030, so it did not provide a scenario for the future costs of transportation fuels.

McKone notes that the damage estimates contained in the report are conservative, meaning the damages are probably higher. The committee focused on generating estimates that are scientifically rigorous and possible to accrue to a specific year. Where this was not possible to calculate, the committee provided ranges and left them out of the estimate provided for 2005.

The report is titled *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*.

— Allan Chen

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A National Academies press release [<http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=12794>] about the report.

More on Thomas McKone's research:

- Thomas McKone's webpage [<http://eetd.lbl.gov/ied/ERA/people/mckone.html>]
  - *The Coming of Biofuels: Study Shows Reducing Gasoline Emissions Will Benefit Human Health* [<http://newscenter.lbl.gov/feature-stories/2009/05/27/biofuels-and-human-health/>]
  - *Tom McKone: What Models Can (and Can't) Tell Us About Risk* [<http://www.lbl.gov/Science-Articles/Archive/sabl/2007/Jan/pollutant-models.html>]
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## Environmental Energy Technologies Division

## NEWS

## Unique Honor Sought for Art Rosenfeld

If 54 co-authors of a recent article in *Environmental Research Letters* have their way, a new unit for electricity savings—the Rosenfeld—will be named after the man seen by many as the godfather of energy efficiency, Lawrence Berkeley National Laboratory (Berkeley Lab) scientist Arthur Rosenfeld.



(Courtesy California Energy Commission)

"In keeping with the tradition among scientists of naming units in honor of the person most responsible for the discovery and widespread adoption of the underlying scientific principle in question," the group of scientists propose to define the Rosenfeld as electricity savings of 3 billion kilowatt-hours per year, the amount needed to replace the annual generation of a 500 megawatt coal-fired power plant.

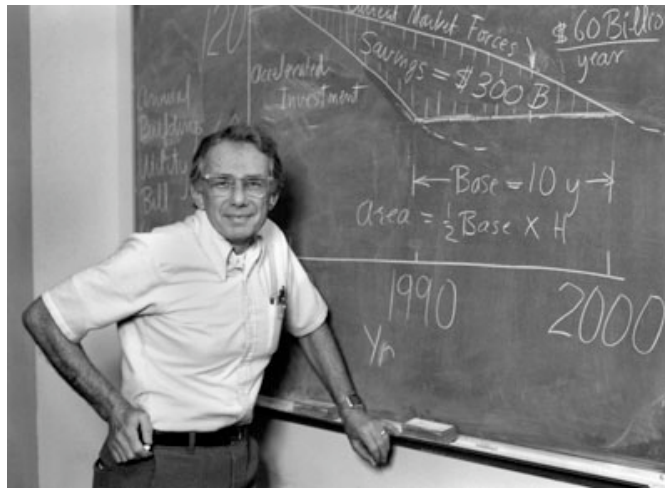
That definition, explains lead author Jonathan Koomey, a Berkeley Lab scientist and consulting professor at Stanford University who was once a graduate student of Rosenfeld's, is classic Rosenfeld. "Power plants are what Art uses most often to explain to policy makers how much electricity can be saved by efficiency investments," Koomey said.

With a decades-long career in energy analysis and standards, Rosenfeld is often credited with being personally responsible for billions of dollars in energy savings. He started his career at the University of California at Berkeley and Berkeley Lab in the 1950s as a physicist in the Nobel Prize-winning particle physics group of Luis Alvarez. However, in 1974, he decided to switch his focus to energy and the environment. A year later, he founded the Center for Building Science at Berkeley Lab, where a broad range of energy efficiency standards and technologies were developed over the next 20 years.

Having just completed two terms on the California Energy Commission, Rosenfeld returns to Berkeley Lab this spring to continue championing scientific solutions for society's most urgent environmental problems.

"He recognized early on, earlier than anyone else I think, that really great gains will come from energy efficiency, that there's an enormity to be gained by this approach," said fellow physicist Richard Muller, who took a graduate course from Rosenfeld in 1965, then went on to work with him in Alvarez's group.

Indeed, the term already named after him—the "Rosenfeld effect"—explains why California's per-capita electricity use has remained flat since the mid-1970s while overall U.S. electricity use has climbed steadily and is now 50 percent higher than it was 40 years ago. Low-emissivity "smart windows," electronic ballasts that led to compact fluorescent lamps, and energy standards for appliances and buildings were Berkeley Lab innovations that made the Rosenfeld effect possible. The term has been popularized by U.S. Secretary of Energy Stephen Chu, who has called Rosenfeld a hero of his.



Art Rosenfeld started working on energy issues at Berkeley Lab in 1974 and is often credited with being personally responsible for billions of dollars in energy savings.

He is also behind "Rosenfeld's Law," which states that the amount of energy required to produce one dollar of economic output has decreased by about 1 percent per year since 1845.

The authors of the article proposing the unit of measurement, entitled "Defining a standard metric for electricity savings," represent 26 institutions from around the world, and include more than a dozen from Berkeley Lab.

Ashok Gadgil, acting director of Berkeley Lab's Energy and Environmental Technologies Division and one of the co-authors, said it's the right unit at the right time. "We're launching this definition at a time when we're on the cusp, I think, from not worrying about carbon emissions to worrying like crazy about carbon emissions. It's also a very practical way to think about energy resources."

Rosenfeld himself is not sure whether to take the whole thing too seriously. "I'm honored that Jon Koomey got 53 of my oldest friends to join together on such a nice thought," he said. He added that he has always tried to explain energy savings in terms that people can grasp, such as the energy use of a home, a car or a power plant. "This nice article is really the result of the early usefulness of using cars, homes, and power plants as an example of savings from energy efficiency," he said.

Not everyone is supporting the new unit, however. Muller, for one, says there are already too many units for measuring energy, such as joules, quads or BTUs, and he would rather see Rosenfeld given a higher honor. "I believe Art Rosenfeld deserves the Nobel Peace Prize more than many people who've received it," Muller said. "Energy conservation has prevented conflict around the world."

Regardless of whether Rosenfeld the unit catches on, Rosenfeld the man has not slowed down. "He'll continue to work on things that catch his imagination, which is the whole world," said Gadgil. "You can't box this guy in."

— Julie Chao

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Download the paper by Koomey et al., "Defining a standard metric for electricity savings [<http://iopscience.iop.org/1748-9326/5/1/014017>]", *Environmental Research Letters*.

View a video of a symposium honoring Art Rosenfeld at UC Davis on March 9, 2010: Rosenfeld symposium videos [<http://eec.ucdavis.edu/rosenfeldvideos/>]

A different version of this story appeared here: "The Rosenfeld" Named After California's Godfather of Energy Efficiency [<http://newscenter.lbl.gov/feature-stories/2010/03/09/the-rosenfeld-unit-of-energy-efficiency/>]

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## Environmental Energy Technologies Division

## NEWS

## Installed Cost of PV in the U.S. Fell in 2008

Researchers at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) released a new study on the installed costs of solar photovoltaic (PV) power systems in the U.S., showing that the average cost of these systems declined by more than 30 percent from 1998 to 2008. Within the last year of this period, costs fell by more than 4 percent.

The number of PV systems in the U.S. has been growing at a rapid rate in recent years, as governments at the national, state, and local levels have offered various incentives to expand the solar market. With this growth comes a greater need to track and understand trends in the installed cost of PV.

"A goal of government incentive programs is to help drive the cost of PV systems lower. One purpose of this study is to provide reliable information about the costs of installed systems over time," says report co-author Ryan Wiser.

According to the report, the most recent decline in costs is primarily the result of a decrease in PV module costs. "The reduction in installed costs from 2007 to 2008 marks an important departure from the trend of the preceding three years, during which costs remained flat as rapidly expanding U.S. and global PV markets put upward pressure on both module prices and non-module costs. This dynamic began to shift in 2008, as expanded manufacturing capacity in the solar industry, in combination with the global financial crisis, led to a decline in wholesale module prices," states the report, which was written by Wiser, Galen Barbose, Carla Peterman, and Naim Darghouth of Berkeley Lab's Environmental Energy Technologies Division.



"Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998–2008" reports a 4 percent drop in installation costs in 2008. In contrast, cost reductions from 1998 through 2007 were largely due to a decline in non-module costs, such as the cost of labor, marketing, overhead, inverters, and the balance of systems.

The study—the second in an ongoing series that tracks the installed cost of PV—examined 52,000 grid-connected PV systems installed between 1998 and 2008 in 16 states. It found that average installed costs, in terms of real 2008 dollars, declined from \$10.80 per watt (W) in 1998 to \$7.50/W in 2008, equivalent to an average annual reduction of \$0.30/W, or 3.6 percent per year in real dollars.

## Region and System Type Influences Costs

Other information about differences in costs by region and by installation type emerged from the study. The cost reduction over time was largest for smaller PV systems, such as those used to power individual households. Also, installed costs show significant economies of scale—small residential PV systems completed in 2008 that were less than 2 kilowatts (kW) in size averaged \$9.20/W, while large commercial systems in the range of 500 to 750 kW averaged \$6.50/W.

Installed costs were also found to vary widely across states. Among systems completed in 2008 and less than 10 kW in size, average costs range from a low of \$7.30/W in Arizona, followed by California, which had average installed costs of \$8.20/W, to a high of \$9.90/W in Pennsylvania and Ohio. Based on these data, and on installed cost data from the sizable German and Japanese PV markets, the authors suggest that PV costs can be driven lower through large-scale deployment programs.

The study also found that the new construction market offers cost advantages for residential PV systems. Among small residential PV systems in California completed in 2008, those systems installed in residential new construction cost \$0.80/W less than comparably-sized systems installed in rooftop retrofit applications.

## Cash Incentives Have Declined

The study also found that the average size of direct cash incentives provided by state and local PV incentive programs declined over the 1998–2008 study period. Other sources of incentives, however, such as federal investment tax credits (ITCs), have increased. For commercial PV systems, the average combined after-tax value of federal and state ITCs, plus direct cash incentives provided by state and local incentive programs, was \$4.00/W in 2008, down slightly from its peak in 2006 but still a near-record-high. Total after-tax incentives for residential systems, on the other hand, were at an historic low in 2008, averaging \$2.90/W, their lowest level within the 11-year study period.

The drop in total after-tax incentives for both commercial and residential PV from 2007 to 2008 more than offset the cost reduction over this period, leading to a slight rise in the net installed cost, or the installed cost facing a customer after receipt of financial incentives. For residential PV, net installed costs in 2008 averaged \$5.40/W, up 1% from the previous year. Net installed costs for commercial PV averaged \$4.20/W, a 5% rise from 2007.

— The Electricity Markets and Policy Group

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For more information, see Electricity Markets and Policy, Renewable Energy [<http://eetd.lbl.gov/EA/EMP/re.html>].

The report *Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998–2008*, by Ryan Wiser, Galen Barbose, Carla Peterman, and Naim Darghouth may be downloaded from Electricity Markets and Policy, Renewable Energy Publications [<http://eetd.lbl.gov/ea/emp/re-pubs.html>].

The research was supported by funding from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (Solar Energy Technologies Program) and by the Clean Energy States Alliance.

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## Environmental Energy Technologies Division

## NEWS

## Berkeley Lab Measurements in Central California Suggest Methane Emissions May Be Underestimated



Berkeley Lab scientist Marc Fischer checks on the equipment.

Emissions of methane, a potent greenhouse gas (GHG), from local sources in California are higher than previously thought, according to direct measurements made by a research team led Marc Fischer at Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division (EETD). Attempting to pinpoint the source of the added emissions, the collaborative team, including EETD and National Ocean and Atmospheric Administration (NOAA) Earth System Research Laboratory scientists, found that livestock may be responsible for emissions larger than those predicted in existing inventories. Similarly, emissions of nitrous oxide, another potent GHG predominantly emitted from fertilizer use, were found to be higher than the existing inventory.

The work on measuring GHG emissions is supported by the California Energy Commission's Public Interest Energy Research (PIER) Program. In 2003, the Energy Commission turned to Berkeley Lab's EETD to begin a theoretical study of estimating GHG emissions. Then in 2006, EETD began the California Greenhouse Gas Emissions (CALGEM) project to initiate a California capability to quantify non-carbon dioxide (CO<sub>2</sub>) greenhouse gas emissions at the regional scale. Now, the California Air Resources Board (CARB) is responsible for implementing the California Global Warming Solutions Act of 2006 (AB32), and it is collaborating with EETD to implement a much larger network to quantify non-CO<sub>2</sub> greenhouse gases emitted by sources across the state.

### Not All Gases Are Created Equal

All greenhouse gases are not created equal—or derived from the same sources. For example, CO<sub>2</sub> is largely produced by fossil-fuel combustion, and as a result those emissions can be estimated and attributed using fuel sales information. However, methane and many other GHGs are largely emitted by biological processes (such as cattle digestive systems and manure management) that cannot be readily metered, making accurate emissions estimates much more difficult. However, the changing GHG content in the atmosphere can be used to estimate the emissions.

Marc Fischer, a staff scientist at Berkeley Lab's EETD, leads the CALGEM effort. He stresses the importance of measuring these gases, noting that despite the headline attention given to CO<sub>2</sub> in climate change discussions, non-CO<sub>2</sub> greenhouse gases also play a substantial role in climate warming. Methane, for example, is about 25 times stronger than CO<sub>2</sub> per unit mass in the radiative forcing that is warming the Earth. Including the relative strength of forcing, the Intergovernmental Panel on Climate Change reports that the global increase in methane from pre-industrial times to the present produces about one quarter of the total increase in radiative forcing beyond the pre-industrial era.



These towers in Walnut Grove California (left) and San Francisco host equipment that measures non-carbon dioxide greenhouse gases in the atmosphere over California.

Fischer neatly sums up its importance to California's greenhouse gas contributions: "Non-carbon dioxide greenhouse gases constitute a small, but non-trivial fraction of California's total emissions."

For the CALGEM project, the EETD-NOAA team collected daily flask sample measurements of all major main greenhouse gases at two radio towers in Central California—one at Sutro Tower in San Francisco and the other in Walnut Grove. In addition, EETD and NOAA measured methane and carbon dioxide continuously at Walnut Grove to identify variations over time in each day. Fischer says: "These are the first long-term, continuous measurements of greenhouse gases focusing on the mixture of urban and rural sources in California."

### Using the Inverse Model to Compare Measurement and Prediction

The study used those measurements to estimate emissions in what is called an *inverse model*, which adjusts the initial emission inventories to provide the best statistical comparison between the measured atmospheric methane mixing ratios and the methane mixing ratios predicted using the methane emission inventories coupled to a model for high-resolution atmospheric transport. In addition to estimating the improved or "posterior" emission estimates, the inverse model also estimates the uncertainties in emissions.

Sharpening the accuracy of the emissions estimates is the cornerstone of this work, and to understand their level of accuracy, it is necessary to quantify the uncertainty in each component of the inverse estimation process.

"This is a key part of the work we are doing," says Fischer. "We spend probably fifty percent of our total time estimating the errors in a quantitative fashion. We quantify those errors using measurements whenever possible, and we have to take each of those errors and add them together appropriately to estimate the significance of our results."

Careful attention to identifying and quantifying these uncertainties is essential to resolving them. Meteorological model uncertainties were identified as the largest source of uncertainty in the emission estimates, so future work will focus on improving the meteorological model and testing the results with measurements from wind profilers and of additional trace gases. The research found that methane emissions in the Central Valley and San Francisco Bay Area are larger than spatially disaggregated emissions derived from existing inventories reported by the California Air Resource Board, and that livestock emissions appear to be the source of the additional methane. Moreover, preliminary unpublished work also shows that nitrous oxide emissions are also underestimated, but that situation varies seasonally, likely depending on agricultural fertilizer use and seasonal climate variations.

### Expanding the Coverage

In part because the work for the Energy Commission demonstrated the effectiveness of the tower measurements, CARB is now planning a collaborative network of towers to achieve statewide coverage. Notes Fischer, "the stations are most effective at measuring the emissions closest to them. Therefore, it's important to have enough stations in key areas to be able to quantify ground sources accurately throughout the state." The network would include the two CALGEM sites, existing sites managed by UC San Diego at Trinidad Head and Scripps Pier, a CARB site above Los Angeles on Mt. Wilson, and five new CARB sites in the Central Valley. By combining the footprints of the different towers, the uncertainties in emissions from different regions could be significantly reduced.

Although this study focused on California, the methods developed in CALGEM could be applied across the United States. "As has been the case with energy efficiency, California continues to lead the way in U.S. efforts to control greenhouse gas emissions," says Fischer.

Fischer presented methane measurement results from the CALGEM project at the Sixth Annual California Climate Change Symposium in September 2009, and also at the American Geophysical Union meeting in December 2009.

CALGEM will be part of California's CalNex 2010 air quality and climate change study in July 2010.

— Mark Wilson

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A report of this research was published in: Zhao, C., A. E. Andrews, L. Bianco, J. Eluszkiewicz, A. Hirsch, C. MacDonald, T. Nehrkorn, and M. L. Fischer (2009), "Atmospheric inverse estimates of methane emissions from Central California," *Journal of Geophysical Research*, 114, D16302, doi:10.1029/2008JD011671.

Find out more about Marc Fischer's research at his web site [<http://eetd.lbl.gov/env/mlf/>].

This research is supported by the California Air Resources Board and the California Energy Commission's Public Interest Energy Research (PIER) Program.

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## Environmental Energy Technologies Division

## NEWS

## No Widespread Impact of U.S. Wind Power Projects on Neighboring Residential Property Values

The United States now has over 30,000 megawatts of installed wind energy capacity, and an increasing number of communities are considering new wind power facilities. Given these developments, there is an urgent need to investigate typical community concerns about wind energy, to provide stakeholders in the wind project siting process with a common knowledge base. One of those concerns is whether or not the property values of nearby homes decline when a wind project is constructed in the vicinity. A report released in December 2009 by the U.S. Department of Energy's (DOE) Lawrence Berkeley National Laboratory evaluated that concern and found that proximity to wind energy facilities does not have a pervasive or widespread adverse effect on the property values of nearby homes.

The DOE-funded report is based on site visits, data collection, and analysis of almost 7,500 single-family home sales, making it the most comprehensive, data-rich analysis to date on the potential impact of U.S. wind projects on residential property values.



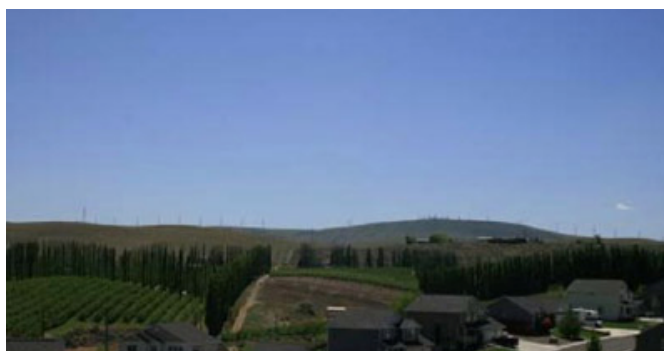
"Neither the view of wind energy facilities nor the distance of the home to those facilities was found to have any consistent, measurable, and significant effect on the selling prices of nearby homes," says report author Ben Hoen, a consultant to Berkeley Lab. "No matter how we looked at the data, the same result kept coming back—no evidence of widespread impacts."

The team of researchers for the project collected data on homes situated within 10 miles of 24 existing wind facilities in nine different U.S. states; the closest home was 800 feet from a wind facility. Each home in the sample was visited to collect important on-site information such as whether wind turbines were visible from the home. The home sales used in the study occurred between 1996 and 2007, spanning the period prior to the announcement of each wind energy facility to well after its construction and full-scale operation.

The conclusions of the study were drawn from eight different hedonic pricing models, as well as repeat sales and sales volume models. A hedonic model is a statistical analysis method used to estimate the impact of house characteristics on sales prices. None of the models uncovered conclusive statistical evidence of the existence of any widespread property value effects that might be present in communities surrounding wind energy facilities.

"It took three years to collect all of the data and analyze more than 50 different statistical model specifications," says co-author and project manager Ryan Wiser of Berkeley Lab, "but without that amount of effort, we would not have been confident we were giving stakeholders the best information possible."

"Though the analysis cannot dismiss the possibility that individual homes or small numbers of homes have been negatively impacted, it finds that if these impacts do exist, their frequency is too small to result in any widespread, statistically observable impact," he added.



The analysis revealed that home sales prices are very sensitive to the overall quality of the scenic vista from a property, but that a view of a wind energy facility did not demonstrably impact sales prices. The Berkeley Lab researchers also did not find statistically observable differences in prices for homes located closer to wind facilities than those located further away, or for homes that sold after the announcement or construction of a wind energy facility when compared to those selling prior to announcement. Even for those homes located within a one-mile distance of a wind project, the researchers found no persuasive evidence of a property value impact.

"Although studies that have investigated residential sales prices near conventional power plants, high-voltage transmission lines, and roads have found some property value impacts," says co-author and San Diego State University Economics Department Chair Mark Thayer, "the same cannot be said for wind energy facilities, at least given our sample of transactions."

— The Electricity Markets and Policy Group

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Electricity Markets and Policy, Renewable Energy [<http://eetd.lbl.gov/EA/EMP/re.html>]

The report, *The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis*, can be downloaded from Electricity Markets and Policy, Renewable Energy Publications [<http://eetd.lbl.gov/ea/emp/re-pubs.html>].

A PowerPoint presentation summarizing key findings from the study is also available [<http://eetd.lbl.gov/ea/ems/emp-ppt.html>].

More information about DOE's Wind and Water Power Program [<http://windandhydro.energy.gov/>].

This research is supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

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## Environmental Energy Technologies Division

## NEWS

**Recovery Act Incentives May Stimulate Community-Scale Wind Projects**

The stimulus package passed in 2009 by Congress may help shovel-ready community wind projects move ahead, according to a new report by Mark Bolinger, a scientist in the Environmental Energy Technologies Division of the U.S. Department of Energy's Lawrence Berkeley National Laboratory. Bolinger analyzed the impact of two new incentives for wind power that were included in the Recovery Act.



"Community wind" power development refers to wind projects that are locally owned (meaning that one or more members of the local community have a significant and direct financial stake in the project, other than through land lease or property tax revenue), consist of utility-scale turbines (generally 100 kilowatts or larger), and are interconnected on either the customer or utility side of the electric meter (i.e., either displacing power purchased from the grid, or selling power directly to the grid, respectively).

According to the report, qualifying wind projects can, for a limited time, choose either a 30% investment tax credit (ITC) or a 30% cash grant in lieu of the production tax credit (PTC) that wind has historically received. To qualify for the 30% ITC, projects must be placed in service by the end of 2012. To qualify for the 30% cash grant, projects must either be operational by the end of 2010, or else must begin construction by then and be placed in service by the end of 2012.

"The analysis shows that community wind, which has had more difficulty using the PTC than commercial wind, may benefit disproportionately from this newfound ability to choose among these federal incentives," says Bolinger.

A financial model of community-scale wind power projects developed by Bolinger indicates that the ITC and cash grant will likely be worth more than the PTC to most community wind projects. Also, several ancillary benefits associated with the ITC or cash grant (but not the PTC)—including full relief from the alternative minimum tax and so-called "passive credit limitations"—could provide a further boost to these projects by enabling them to capture the full value of the incentive.

"Quantitative analysis of these ancillary benefits also informs the development of a policy agenda for community wind, by revealing which of these benefits are most valuable to the sector," says Bolinger. "For example, the analysis highlights the importance of the 30% cash grant for passive investors in community wind projects. In this light, seeking to extend the very limited window of opportunity (afforded by the current legislation) for the 30% cash grant may be a logical top policy priority for the community wind sector."

— Allan Chen



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Electricity Markets and Policy, Renewable Energy [<http://eetd.lbl.gov/EA/EMP/re.html>]

Read the full report: *Revealing the Hidden Value that the Federal Investment Tax Credit and Treasury Cash Grant Provide to Community Wind Projects* [<http://eetd.lbl.gov/EA/EMP/re-pubs.html>]

This research is supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

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## Environmental Energy Technologies Division

## NEWS

## FABS21 Benchmarking Tool Helps Semiconductor Manufacturers Improve Energy Efficiency

Scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), in cooperation with the International SEMATECH Manufacturing Initiative (ISMI), have released for beta testing a computer-based tool to help the world's semiconductor manufacturing facilities ("fabs") evaluate and improve their energy efficiency.

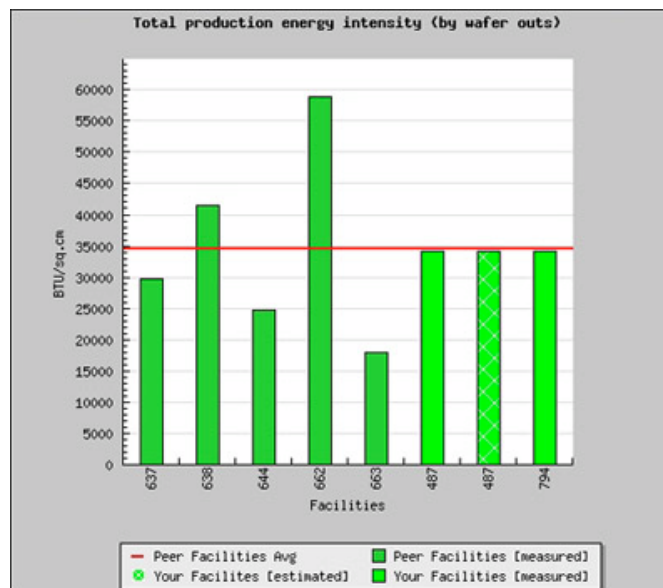
"We developed FABS21 to allow the operators of semiconductor manufacturing facilities to continuously benchmark and improve energy and water efficiency of semiconductor facilities," says Paul Mathew, a Staff Scientist in the Environmental Energy Technologies Division (EETD) of Berkeley Lab.

"Resource efficiency is not just an environmental initiative; it is also an important business process that can reduce costs for fabs," said James Beasley, Environment, Safety and Health (ESH) Technology Manager for ISMI. "ISMI is pleased to be partnering with Berkeley Labs on this project. Finding ways to conserve resources is vital to the long-term growth of the semiconductor industry, and tools such as the FABS21 benchmark database help ISMI and the industry address the challenges of sustainable manufacturing."

Benchmarking is the process of comparing a building's or facility's energy and water use to those of its peers.

The tool draws on previous research at Berkeley Lab on benchmarking for high-technology facilities such as laboratories, data centers, and clean rooms. It also makes use of the survey methods and data collected through the Semiconductor Industry Association (SIA). Berkeley Lab researchers worked with ISMI's Green Fab working group to validate the benchmarking methodology. Development of FABS21 is sponsored by ISMI, the global consortium of the world's major semiconductor manufacturers.

Users can benchmark their facilities using up to 46 different building and system level metrics, which fall into two categories. They can benchmark the overall facility energy and water efficiency, as kilowatt-hours/square centimeter of wafer output, and gallons per square foot of manufacturing space. These metrics will help facility operators who are applying for certification in the LEED-EBOM (Existing Buildings Operations and Maintenance) rating system.



FABS21 also gives users system-level metrics, which are used for "action-oriented benchmarking." That is, with this information, users can identify potential actions to improve specific system areas such as ventilation air flow efficiency (in watts per cubic feet per minute), and chiller plant efficiency (in kilowatts per ton). The tool has metrics for environmental conditions, ventilation, cooling and heating, process equipment, and lighting and electrical systems.

Users can benchmark a facility across a set of years, as well as compare it to a group of similar facilities. They can filter the peer facilities dataset based on climate zone, facility type, and cleanliness level.

Development team members include Paul Mathew, Martin Stoufer, of the Information Technology division, and Anthony Ma of EETD.

— Allan Chen

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FABS21 Beta Tool <http://fabs21.lbl.gov/> website.

High technology buildings research <http://hightech.lbl.gov/> at Berkeley Lab.

More about the International SEMATECH Manufacturing Initiative <http://ismi.sematech.org/>.

LEED for Existing Buildings <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=221>].

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## Environmental Energy Technologies Division

## NEWS

## Data Center Energy Efficiency Project Wins Best of California Award

A project to improve the energy efficiency of the State of California Franchise Tax Board's data center has won a "Best of California" Award from the Center for Digital Government. Geoffrey Bell, Energy Engineer at Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division, led the project team.



The research was funded by the California Energy Commission's Public Interest Energy Research (PIER) program, and other participants included Federspiel Controls, Inc., Emerson Network Power, and California's Department of General Services.

The Franchise Tax Board (FTB) is the California agency responsible for collecting state taxes. Its 10,000-square-foot data center in Sacramento was kept cool by 12 computer room air handling units (CRAHs), each one with a 22-ton capacity for chilling the cooling water. Data servers generate considerable heat, so data center designers tend to overdesign cooling capacity, typically providing more cooling capacity than is actually necessary. At the FTB, all 12 CRAHs were kept on all the time. There was no sensor system to coordinate the CRAHs cooling the room, so there was no way to tell whether it could be conditioned adequately with fewer units.

The project team conducted a complete evaluation of the data center's energy use and installed a number of energy-saving retrofits, the centerpiece of which was a relatively inexpensive "wireless" control system for the CRAHs.

"This project demonstrated that a wireless sensing network could directly control computer room air conditioning devices, maintaining an optimum temperature, while saving energy," says Bell. The project team installed a wireless control system developed by Federspiel Controls, Inc., which included a wireless mesh-network of 46 temperature sensors at various locations around the center. The mesh network provided air-temperature feedback from the server-equipment air inlets to the control system that determined which of the 12 CRAH cooling units were needed to operate, and to reset the setpoints of the remaining operating units. The Federspiel control technology is called a Data Automation Software and Hardware (DASH) System.

The DASH temperature sensors provided information that had not been available previously—real-time information on how cool various points in the center were. The DASH system could turn on and off the appropriate CRAH units to maintain the desired air temperature. This technology could also "learn" from operational experience: as it logged more and more data on how the temperature responded to the manipulation of the CRAH units, the DASH system actually further reduced energy consumption by managing these units more efficiently over time.

Once the control DASH system was working, the facility team learned that they could turn off eight of the 12 CRAHs and keep the data center cool using just the remaining four units.

The project team also took other steps from an array of energy-efficient data center measures developed as a result of research conducted at Berkeley Lab. A simple one was to make sure that the floor tiles were correctly positioned for proper air distribution. The FTB server racks sit on a raised floor. The improved floor tile arrangement helped manage airflow to supply cool air to the server inlets within temperature limits recommended by ASHRAE, the Association of Heating, Refrigeration and Air Conditioning Engineers. They also installed fusible-link air curtains to isolate cold-air supply from hot-air return, and variable frequency drives to make the CRAH fans more energy-efficient. These efforts resulted in a decrease of chilled water use and more energy savings.

In sum, the measures eliminated the use of more than 475,000 kilowatt-hours per year, which is 21.3 percent of the data center's baseline energy consumption. This also represents an elimination of more than 400 tons of carbon dioxide emissions annually. The wireless control alone was responsible for about 15 percent of these savings. Fan energy use decreased by 66 percent. All of the measures together will save about \$43,000 per year in energy costs, so the cost of the work will pay for itself in about two years.

At a ceremony in Sacramento in December, the Center for Digital Government gave the Franchise Tax Board its 2009 Best of California Award in the Green IT category for this project. The Best of California Awards program salutes IT professionals and projects in California state and local government organizations and educational institutions.

— Allan Chen

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Center for Digital Government [<http://www.centerdigitalgov.com/>]

Best of California Award 2009 [<http://www.centerdigitalgov.com/survey/2581>] information.

More on energy-efficient data center demonstration projects [<http://hightech.lbl.gov/demonstrations.html>] at Berkeley Lab.

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# Environmental Energy Technologies Division

## NEWS

### Sources and Credits

#### Sources

##### DOE's Consumer Information Fact Sheets

These web pages [<http://www.eere.energy.gov/consumer/>] provide information about energy efficiency and renewable energy for your home or workplace.

##### DOE's Energy Information Administration (EIA)

EIA [<http://www.eia.doe.gov/>] offers official energy statistics from the U.S. Government in formats of your choice, by geography, by fuel, by sector, or by price; or by specific subject areas like process, environment, forecasts, or analysis.

##### DOE's Fuel Economy Guide

This website [<http://www.fueleconomy.gov/>] is an aid to consumers considering the purchase of a new vehicle.

##### DOE's Office of Energy Efficiency & Renewable Energy (EERE)

EERE's [<http://www.eere.energy.gov/>] mission is to pursue a better energy future where energy is clean, abundant, reliable, and affordable; strengthening energy security and enhancing energy choices for all Americans while protecting the environment.

##### U.S. DOE, Office of Science [<http://www.er.doe.gov/>]

##### U.S. EPA, ENERGY STAR Program [<http://energystar.gov/>]

##### California Energy Commission [<http://energy.ca.gov/>]

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With more than 4,000 employees, Berkeley Lab's total annual budget of nearly \$600 million supports a wide range of unclassified research activities in the biological, physical, computational, materials, chemical, energy, and environmental sciences. The Laboratory's role is to serve the nation and its scientific, educational, and business communities through research performed in its unique facilities, to train future scientists and engineers, and to create productive ties to industry. As a testimony to its success, Berkeley Lab has had 11 Nobel laureates. EETD is one of 14 scientific divisions at Berkeley Lab, with a staff of 400 and a budget of \$40 million.

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